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DRAWINGS ATTACHED

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(72) Inventors JOHN WELDON HALL and JOSEPH FRANCIS VERCELLOTTI

(54) SOLID STATE FIBER OPTICS DEVICE

(71) We, GENERAL ELECTRIC COMPANY, a corporation organized and existing under the laws of the State of New York, United States of America, of 1 River Road, Schenectady 12305, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to solid state fiber optics devices.

More particularly, the invention is in the field of fiber optics light devices, in which light (visible or infrared) is transmitted or "piped" through a fiber optics light conductor or through a bundle of such conductors. For example, an arrangement for optically reading ten-column punched tape in data processing equipment, employs a bundle of ten fiber optics light conductors having the light-exiting ends thereof arranged transversely adjacent to the moving tape and respectively in alignment with the ten columns of punched openings. Ten small photocells are positioned adjacent to the other side of the tape and respectively in alignment with the light-exiting ends of the fiber optics, so as to optically read the characters represented, on the moving tape, by the presence and absence of openings. There are many other uses for fiber optics light systems.

In fiber optics light devices the light source, positioned near the light-receiving ends of the fiber optics conductors has been an incandescent, fluorescent, gas discharge, or solid state lamp. For economy and other reasons it has been desirable to increase the efficiency of light coupling between the lamp and the fiber optics, and one way of achieving improved efficiency has been to grind and polish optically flat a surface of the lamp and also the light-receiving ends of the fiber optics conductors, and to position the ends of the fiber optics conductors flatly and firmly against the surface of the lamp. It has been particularly desirable to increase the efficiency of the fiber optics light coupling when a solid state lamp is used as the light source, because of the low level of brightness of solid state lamps.

The present invention seeks to provide an optically efficient fiber optics device in which the light source is a solid state lamp.

The solid state fiber optics device in accordance with this invention comprises a header, a solid state light emitting diode, at least one fiber optics conductor having an end thereof positioned near said diode to receive light therefrom, a shell attached to said header and surrounding said diode and said fiber optics conductor or conductors, and a solid, light-transmitting encapsulating material of refractive index greater than unity within the shell between and in intimate molded contact with said diode and with said end of the or each fiber optics conductor, the encapsulating material surrounding said end of the or each fiber optics conductor to hold it in position with respect to said diode and serving to transmit light from said diode to said end of the or each fiber optics conductor.

The present invention also provides a method of making the solid state fiber optics device just defined, which comprises the steps of mounting the diode on the header, attaching the shell to the header so as to surround the diode, pouring the encapsulant in pre-hardened, liquid state into said shell, inserting an end of the or each fiber optics conductor into said encapsulant and holding said fiber optics conductor or conductors in position until the encapsulant hardens.

The invention will now be further described with reference to the accompanying drawings, in which:

Fig. 1 is a cross-sectional view of a preferred embodiment of the invention, taken on the line 1—1 of Fig. 2, and

Fig. 2 is a top view of the preferred embodiment.

The embodiment of the invention shown in the drawings, comprises a solid state light-emitting diode 11 mounted on a circular metal header 12. An electrical connection lead 13 extends from the header 12, and a second electrical connection lead 14 extends through an opening in the header 12 and is insulated therefrom by an insulator 16. A connector wire 17 connects the inner end of the lead 14 to the upper surface of the diode element 11, the lower surface of the diode 11 being electrically connected to the lead 13 via the header 12. A circular shell 18, preferably of metal but which can be of a plastic material, is concentrically positioned on the header 12 and welded or otherwise attached thereto at a flange 19. For further details of a suitable light-emitting diode 11 and its attachment to a header having a surrounding shell, reference may be made to U.S. Patent 3,458,779.

A bundle 21 of fiber optics conductors 23 has an end thereof positioned within the shell 18, in proximity to and in alignment over the light-emitting diode 11, and the shell 18 is filled with an encapsulant 22 which surrounds the ends of the fiber optics conducts to hold them in position with respect to the diode 11 and which also provides efficient optical coupling between the diode 11 and the lower ends of the fiber optics 21, as will be described more fully. The fiber optics 21, as shown in the drawing, consists of ten individual light conductors 23 which may be of any desired length and preferably are flexible as indicated at 23^1. However, one may use any number of fiber optic light conductors depending upon the application.

Suitable materials from which the diode 11 is made, such as gallium arsenide, gallium phosphide, and silicon carbide, have relatively high indices of light refraction, and hence have an undesirably small critical angle at which the light, which is emitted at a junction in the diode, can escape through the upper surface of the diode element. Due to refraction of light rays at the exiting surface of the diode, the emitted light radiates in a hemispherical pattern. The rest of the upwardly directed light within the diode becomes reflected, at the upper diode surface, back into the diode and becomes dissipated due to absorption in the diode material. The expedient that is used in accordance with the invention for increasing the critical angle of the diode, and hence increasing the area of light exiting from the surface of the diode, which in turn permits more light to escape from the diode thereby increasing the efficiency, is to encapsulate the light exiting diode surface with a material having a refractive index greater than unity, i.e., greater than that of air.

In this way, the amount and intensity of light that exits from the diode 11 and enters the nearby end of the fiber optics bundle is increased, thus increasing the efficiency and making solid state fiber optics light sources more feasible than heretofore. Suitable materials for the encapsulant 22 are glass, or plastics such as an acrylic, or epoxies, which have an index of refraction greater than unity and which bond the end of the fiber optic bundle 21 in position.

A preferred method of manufacturing the device shown in the drawings comprises the steps of assembling the diode 11 onto the header 12, attaching the shell 18 to the header 12, pouring the encapsulant 22 in prehardened liquid form into the shell 18, inserting the fiber optics bundle 21 into the liquid encapsulant 22, and holding it in desired position while the encapsulant hardens. Any excess encapsulant which spills over the rim of the shell 18 may be wiped off or trimmed away. After hardening, the encapsulant is in intimate molded contact with the diode 11 and the ends of the fiber optics conductors 23.

WHAT WE CLAIM IS:—

1. A solid state fiber optics device comprising a header, a solid state light emitting diode, at least one fiber optics conductor having an end thereof positioned near said diode to receive light therefrom, a shell attached to said header and surrounding said diode and said fiber optics conductor or conductors, and a solid, light-transmitting encapsulating material of refractive index greater than unity within the shell between and in intimate molded contact with said diode and with said end of the or each fiber optics conductor, the encapsulating material surrounding said end of the or each fiber optics conductor to hold it in position with respect to said diode and serving to transmit light from said diode to said end of the or each fiber optics conductor.

2. A solid state fiber optics device according to Claim 1 and comprising a plurality of said fiber optics conductors arranged as a bundle.

3. A method of making a solid state fiber optics device according to Claim 1, comprising the steps of mounting the diode on the header, attaching the shell to the header so as to surround the diode, pouring the encapsulant in prehardened, liquid state into said shell, inserting an end of the or each fiber optics conductor into said encapsulant, and holding said fiber optics conductor or conductors in position until the encapsulant hardens.

4. A method of making a solid state fiber optics device, according to Claim 3 and sub-

stantially as hereinbefore described with reference to the accompanying drawings.

5. A solid state fiber optics device whenever made by a method according to Claim 3 or Claim 4.

6. A solid state fiber optics device, substantially as hereinbefore described with reference to the accompanying drawings.

TREGEAR, THIEMANN & BLEACH,
Chartered Patent Agents,
Melbourne House,
Aldwych,
London, W.C.2,
Agents for the Applicants.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig. 1.

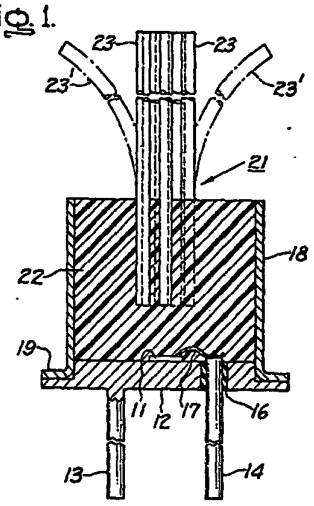

Fig. 2.